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(71) Applicant (*for all designated States except US*): **BOARD OF REGENTS** [US/US]; The University of Texas System, 201 W. Seventh Street, Austin, TX 78701 (US).

(72) Inventor; and

(75) Inventor/Applicant (*for US only*): **GOLDSTEIN, David, B.** [US/US]; 7700 Chimney Corners Dr., Austin, TX 78731-1525 (US).

(74) Agent: **NAVARRO, Arthur, I.**; Godwin Gruber, LLP, Renaissance Tower, 1201 Elm St., Suite 1700, Dallas, TX 75270-2084 (US).

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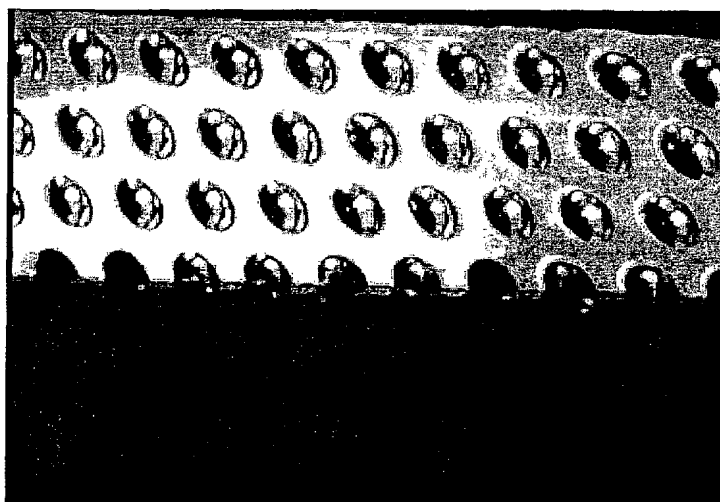
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(54) Title: METHODS FOR REDUCING THE VISCOUS DRAG ON A SURFACE AND DRAG REDUCING DEVICE



Test article showing a large number of flush bubbles held in holes of the type seen in figures 2a, 2b and 2d. The hole diameters are 1/8th inch. The substrate is an aluminum perforated plate backed by a sticky tape. Note that the bubbles remain essentially flush even though the substrate is held roughly vertical. That is, the bubbles do not rise out and are held in place by surface tension. The water is not flowing.

(57) Abstract: A submerged surface is created, either as an add-on application or as an integral part of the submerged structure, having an array of closely spaced small bubble-filled holes which cover a large fraction of the wetted surface area. The viscous drag on the bubbles is much smaller than that on the surrounding solid surface and the net drag on the entire submerged surface is less than that on an equivalent solid surface.



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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/12950

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B63B1/38

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B63B G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 238 434 A (MORAN STEVEN M) 24 August 1993 (1993-08-24)	1,4,5
Y	column 6, line 18 -column 7, line 39; figures 4,6-8	3,5,32
Y	EP 0 894 705 A (ISHIKAWAJIMA HARIMA HEAVY IND ;KATO HIROHARU (JP)) 3 February 1999 (1999-02-03) column 7, paragraph 40 - paragraph 41; claim 1; figures 3,4,6 --- -/--	32

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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- \*&\* document member of the same patent family

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European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Moya, E

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>FONTAINE A A ET AL: "THE INFLUENCE OF THE TYPE OF GAS ON THE REDUCTION OF SKIN FRICTION DRAG BY MICROBUBBLE INJECTION" EXPERIMENTS IN FLUIDS, SPRINGER VERLAG. BERLIN, DT, vol. 13, no. 2 / 3, 1992, pages 128-136, XP000293893 ISSN: 0723-4864 abstract</p> <p style="text-align: center;">---</p>	6,7,30
Y	<p>US 3 213 819 A (GRIFFITH MAY) 26 October 1965 (1965-10-26)</p>	3,5
A	<p>column 3, line 14 -column 5, line 30; figure 3</p> <p style="text-align: center;">---</p>	14-16
A	<p>WO 91 01247 A (VELKE HANS WILLI) 7 February 1991 (1991-02-07) page 4, line 5 -page 5, line 16; figures</p> <p style="text-align: center;">---</p>	1-11
A	<p>US 5 171 623 A (YEE NORMAN D) 15 December 1992 (1992-12-15) column 3, line 66 -column 4, line 20; figures 2-4B</p> <p style="text-align: center;">-----</p>	1-11

# INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/US 03/12950

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5238434	A	24-08-1993	AU 642809 B2 AU 1103492 A	28-10-1993 01-10-1992
EP 0894705	A	03-02-1999	JP 11049080 A JP 11152077 A BR 9802815 A CA 2242698 A1 CN 1208128 A EP 0894705 A2 FI 981669 A NO 983469 A TW 403815 B US 6092480 A	23-02-1999 08-06-1999 03-11-1999 01-02-1999 17-02-1999 03-02-1999 02-02-1999 02-02-1999 01-09-2000 25-07-2000
US 3213819	A	26-10-1965	NONE	
WO 9101247	A	07-02-1991	AU 6037390 A WO 9101247 A1	22-02-1991 07-02-1991
US 5171623	A	15-12-1992	CA 2082201 A1	06-05-1994